

OU1 Mann-Kendall Analysis Summary Report for Groundwater on and Near the Yerington Paiute Tribe Reservation

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1 Introduction

Mann-Kendall trend test (M-K) was performed on YPT monitoring wells (YPT-MW) 8, 9, 10, 11, 12, 13, 14, and 15 as well as Wells off reservation (BW) 10, 53, 54, 69, and 81 which are in the North Study Area (NSA) located northeast of West Campbell Ditch and north of the Sunset Hills in Yerington. M-K was completed for alkalinity, arsenic, pH, sulfate, and uranium. YPT MW-6 only had water levels, no data on constituents therefore it was not included in the M-K analysis.

The majority of data was collected by Brown and Caldwell for the responsible party (RP), Atlantic Richfield Company (ARC), a wholly owned division of BP. The Scope of Work (SOW) requires ARCs investigation on the magnitude of mine-related groundwater impact and to develop baseline background groundwater quality assessment for chemicals of interest (COIs) within study areas.

Mann-Kendall trend test for drinking water of Domestic Wells (DW or PW) PW-4 and PW-5 were also analyzed. A trend test was performed for uranium, arsenic and bicarbonate from routine samples collected from 2002 to 2016. The data comes from YPT, data and/or samples in the B&C database for these wells appear to have been mishandled and are likely an un-marked combination of the two wells. The Tribal water system uses both wells on a daily basis and ARC samples may have come from a combined flow.

2 Methods

All data results that had comments were evaluated for inclusion or exclusion for M-K analysis and for compatibility with ProUCL_5.1 software. Data flags associated with “J” were included in MK analysis while data flags with “U” or “UJ” were replaced with their corresponding Non-Detect (ND) values.

Currently ProUCL_5.1 only works with dates in chronological order and “does not read dates (years, quarters etc.)” (ProUCL 5.1 technical guide). Therefore, dates and times were arranged in chronological order prior to M-K analysis.

Excel “find” function was run for the data to determine if there were duplicates. There were no duplicate samples for the parameters analyzed. The same was done for Non-detect (ND). Where NDs were found, were replaced with corresponding ND values.

The drinking water samples did not have NDs, “U” or ‘UJ” associated with the dataset for the parameters analyzed.

2.1 Data Organization for ProUCL Mann-Kendall Trend Analysis

Prior to trend analysis, data sets are separated into categories of wells and parameters such as

alkalinity bicarbonate and alkalinity total, arsenic, pH, sulfate, and uranium in excel spread sheets. The data is arranged in chronological order using collection or sampling dates which are then assigned numbers for ProUCL to accept.

Currently ProUCL 5.1 software does not recognize ND values therefore, NDs values were assigned the lowest detectable value (DL) for that specific sample.

2.2 Mann-Kendall Trend Analysis

Mann-Kendall is used to determine data trend, in this case, trends in concentration with time. M-K considers all possible pairs of measurements in the data and scores them. It scores them as follows:

- a. Earlier measurement with a lower magnitude than a later one is assigned 1.
- b. Earlier measurement higher in magnitude than a later sample is assigned -1.
- c. Two identical measurement values are assigned 0.
- d. ND values are assigned a common value lower than any of the measurements when applicable (ND where assigned values for this data set).

The scored values are summed up to get the M-K statistic S. A positive value of S suggests an upward (increasing) trend over time while a negative value of S suggests a downward (decreasing) trend over time. S values closer to zero suggests equal number of negative and positive differences. Only when the absolute value of S is larger than the critical point is there a statistically significant increasing or decreasing trend. Since ProUCL 5.1 does not recognize M-K ones and zeros, data is arranged according to software requirements and run for trend determination using the M-K trend analysis function.

3 Results

Several of the M-K trend test results for the parameters are statistically significant and there are evidences of increasing trend at the specified level of significance (0.05).

M-K trend test analysis function automatically calculates the general statistics and M-K trend analysis in a spread sheet summary format. Table 1 and Appendix A shows a summary of: 1) general statistics such as: number of samples, minimum, maximum, mean, geometric mean, median, standard deviation, and coefficient of variation, 2) M-K statistics: M-K test value (S), tabulated p-value, standard deviation, standardized value of S, approximate p-value, and the M-K trend.

3.1 YPT Monitoring Wells

Table 1 is a summary of the M-K trend analyses for YPT monitoring wells and Wells off reservation (BW) for alkalinity bicarbonate, alkalinity total, arsenic, pH, sulfate, and uranium.

alkalinity bicarbonate and alkalinity total had an increasing trend in wells MW-9I, MW-12I, MW-13I, and MW-14D1. There was an increasing trend in alkalinity bicarbonate in MW-10B. No trend or insufficient evidence for both constituents in wells MW-11S, MW-15I and for alkalinity total in well MW-10B.

Arsenic showed an increasing trend in wells MW-13I and MW-12I while MW-15I, and MW-14D1 had decreasing trends. No trends were observed in wells MW-9I, MW-10B, and MW-11S.

No trends were observed for pH in the YPT monitoring wells.

Sulfate had a downward trend in wells MW-9I and MW-10B and insufficient evidence for a trend in the other wells.

Uranium trended upwards in wells MW-14D1 and MW-13I however, there was a downward trend in MW-11S. There were no trends for the other wells and no data for uranium on MW-12I.

3.2 Wells off Reservation (BW)

Among the wells off reservation BW10D1 and BW81D1 trended upward for alkalinity. All the other wells did not have sufficient evidence for a conclusive trend. Arsenic trended upward in wells BW53S2 and BW69D5 and downward in BW10I and BW10S. All the wells off reservation lacked sufficient evidence for a trend on pH except for BW53S2 which had a decreasing trend.

Wells BW10D1 and BW69D5 had an increasing trend for sulfate while wells BW54B, BW54I, BW54I, BW54S showed decreasing trends. Uranium trended upward for BW10D1, BW53B, and BW81D2 and downward for BW10S, BW54I, BW54S, BW69S, and BW81S.

3.3 PW-4 and PW-5 Municipal Supply Wells

Both uranium and Sulfate concentrations were increasing in PW-5 while arsenic was decreasing. There was no trend in PW-4 for uranium, arsenic, and sulfate from the M-K trend analysis results. Seasonal M-K did not show enough data points for analysis.

4 References

ProUCL_5.1 technical guide and PoUCL_5.1 software. Retrieved on 15 October 2016.
<https://www.epa.gov/land-research/proucl-version-5100-documentation-downloads>.

EPA Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, unified guidance (March 2009). Retrieved on 01 October 2016. <https://nepis.epa.gov/Exe/ZyNET.exe/P10055G>

5 Tables

Table 1. Summary table of Mann-Kendall trend analysis results.

YPT Monitoring Wells (YPT MW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
MW-9I	Alkalinity, Bicarbonate	15	110	150	63	7.17E-04	I
	Alkalinity, Total	15	110	150	63	7.17E-04	I
	Arsenic	15	6.6	7.9	-28	0.0869	NT
	pH	15	7.68	8.11	1	0.5	NT
	Sulfate	15	33	39	-36	0.0392	D
	Uranium	15	8.7	11	18	0.191	NT
MW-10B	Alkalinity, Bicarbonate	15	88	130	35	0.037	I
	Alkalinity, Total	16	88	130	22	0.16	NT
	Arsenic	16	19	21	-7	0.38	NT
	pH	16	8	8.42	20	0.196	NT
	Sulfate	16	25	30	-69	6.12E-04	D
MW-11S	Uranium	16	8.3	11	-10	0.342	NT
	Alkalinity, Bicarbonate	5	120	150	-7	0.0648	NT
	Alkalinity, Total	5	120	150	-7	0.0648	NT
	Arsenic	5	6.3	8.3	-6	0.11	NT
	pH	5	7.3	7.84	-4	0.231	NT
	Sulfate	5	44	64	3	0.307	NT
	Uranium	5	6.6	20	-8	0.0432	D

Key		
Increasing Trend		I
Decreasing Trend		D
No Trend		NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

YPT Monitoring Wells (YPT MW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
MW-13I	Alkalinity, Bicarbonate	16	88	140	64	0.00181	I
	Alkalinity, Total	16	88	140	64	0.00181	I
	Arsenic	16	5.8	8.1	56	0.00655	I
	pH	16	7.49	7.93	29	0.103	NT
	Sulfate	16	33	42	-36	0.0553	NT
	Uranium	16	4.6	9.1	95	1.09E-05	I
MW-14D1	Alkalinity, Bicarbonate	16	92	130	38	0.0442	I
	Alkalinity, Total	16	92	130	38	0.0442	I
	Arsenic	16	15	19	-40	0.0352	D
	pH	16	7.61	8.16	-28	0.111	NT
	Sulfate	16	29	38	-12	0.307	NT
	Uranium	16	10	18	47	0.017	I
MW-15I	Alkalinity, Bicarbonate	12	230	340	19	0.105	NT
	Alkalinity, Total	12	230	340	19	0.105	NT
	Arsenic	12	5.7	6.5	-39	0.00363	D
	pH	12	6.82	8.05	-1	0.5	NT
	Sulfate	12	42	56	-13	0.204	NT
	Uranium	12	15	34	10	0.269	NT
MW-12I	Alkalinity, Bicarbonate	16	160	260	38	0.0443	I
	Alkalinity, Total	16	160	260	38	0.0443	I
	Arsenic	16	3.6	5.6	-41	0.0347	I
	pH	16	6.64	7.74	11	0.326	NT
	Sulfate	16	72	270	-34	0.0683	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Wells off Reservation (YPT MW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
BW 10D1	Alkalinity, Bicarbonate	41	72	180	310	2.39E-04	I
	Alkalinity, Total	41	72	180	310	2.39E-04	I
	Arsenic	41	7.7	14	-306	2.41E-04	D
	pH	41	7.25	8.33	72	0.212	NT
	Sulfate	41	33	56	414	1.67E-06	I
	Uranium	41	5.4	25	358	2.97E-05	I
BW 10S	Alkalinity, Bicarbonate	30	100	140	47	0.193	NT
	Alkalinity, Total	30	100	140	47	0.193	NT
	Arsenic	29	4.5	6.7	-104	0.0259	D
	pH	30	7.21	8.2	59	0.15	NT
	Sulfate	30	29	120	9	0.443	NT
	Uranium	28	2.4	5.3	-93	0.034	D
BW 53B	Alkalinity, Bicarbonate	20	110	160	28	0.18	NT
	Alkalinity, Total	20	110	160	28	0.18	NT
	Arsenic	20	6.3	16	45	0.0654	NT
	pH	20	7.7	8.18	-49	0.0591	NT
	Sulfate	20	140	170	-47	0.038	D
	Uranium	20	8.8	11	79	0.00464	I
BW 53S2	Alkalinity, Bicarbonate	17	120	140	4	0.446	NT
	Alkalinity, Total	17	120	140	4	0.446	NT
	Arsenic	17	11	15	49	0.00928	I
	pH	17	7.7	8.19	-45	0.0348	D
	Sulfate	17	140	170	-30	0.0943	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Wells off Reservation (BW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
BW 54B	Uranium	17	8.4	12	31	0.105	NT
	Alkalinity, Bicarbonate	15	110	150	3	0.458	NT
	Alkalinity, Total	15	110	150	3	0.458	NT
	Arsenic	15	22	28	3	0.459	NT
	pH	15	7.56	8.2	-20	0.173	NT
	Sulfate	15	63	80	-36	0.0406	D
BW 54I	Uranium	15	15	20	-11	0.306	NT
	Alkalinity, Bicarbonate	15	140	180	7	0.372	NT
	Alkalinity, Total	15	140	180	7	0.372	NT
	Arsenic	15	21	26	-17	0.199	NT
	pH	15	7.93	8.3	-7	0.383	NT
	Sulfate	15	57	73	-36	0.0406	D
BW 54S	Uranium	15	30	38	-54	0.00379	D
	Alkalinity, Bicarbonate	15	140	180	-11	0.292	NT
	Alkalinity, Total	15	140	180	-11	0.292	NT
	Arsenic	15	18	21	3	0.458	NT
	pH	15	7.83	8.21	-5	0.421	NT
	Sulfate	15	41	71	-64	8.46E-04	D
BW 69D1	Uranium	15	20	31	-54	0.00349	D
	Alkalinity, Bicarbonate	6	230	250	-9	0.05	D
	Alkalinity, Total	6	230	250	-9	0.05	D
	Arsenic	6	3.7	4	5	0.205	NT
	pH	6	7.5	8.08	3	0.354	NT
	Sulfate	6	97	120	-9	0.0595	NT
	Uranium	6	50	59	1	0.5	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Wells off Reservation (BW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
BW 69D2	Alkalinity, Bicarbonate	6	110	130	1	0.5	NT
	Alkalinity, Total	6	110	130	1	0.5	NT
	Arsenic	6	5.4	5.8	-2	0.421	NT
	pH	6	7.91	8.21	9	0.0664	NT
	Sulfate	6	32	47	1	0.5	NT
	Uranium	6	5.9	11	5	0.226	NT
	Alkalinity, Bicarbonate	5	160	210	-6	0.0958	NT
BW 69D5	Alkalinity, Total	5	160	220	-5	0.156	NT
	Arsenic	5	6.4	13	8	0.0432	I
	pH	5	8.1	8.61	-4	0.231	NT
	Sulfate	5	34	41	9	0.0216	I
	Uranium	5	2.9	4.3	-2	0.403	NT
BW 69S	Alkalinity, Bicarbonate	6	230	280	-6	0.169	NT
	Alkalinity, Total	6	230	280	-6	0.169	NT
	Arsenic	6	1.9	3.1	-8	0.0903	NT
	pH	6	7.22	8.08	7	0.13	NT
	Sulfate	6	120	130	5	0.191	NT

Key	
Increasing Trend	I
Decreasing Trend	D
No Trend	NT

Table 1 Continued. Summary table of Mann-Kendall trend analysis results.

Wells off Reservation (BW)							
Well Number	Constituents	Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
	Uranium	6	7.8	30	-11	0.0301	D
BW 81D1	Alkalinity, Bicarbonate	5	220	230	-6	0.0745	NT
	Alkalinity, Total	6	220	240	-11	0.0199	D
	Arsenic	6	6.6	7.5	4	0.283	NT
	pH	6	7.43	8.11	7	0.13	NT
	Sulfate	6	68	83	4	0.283	NT
	Uranium	6	36	47	4	0.283	NT
BW 81D2	Alkalinity, Bicarbonate	6	190	200	4	0.244	NT
	Alkalinity, Total	6	190	200	4	0.244	NT
	Arsenic	6	4.1	4.6	0	N/A	NT
	pH	6	7.77	8.15	7	0.13	NT
	Sulfate	6	46	57	6	0.169	NT
	Uranium	6	34	43	12	0.0134	I
BW 81S	Alkalinity, Bicarbonate	5	140	160	-7	0.048	D
	Alkalinity, Total	5	140	160	-7	0.048	D
	Arsenic	5	4.3	5.1	-7	0.0648	NT
	pH	5	7.11	7.8	6	0.11	NT
	Sulfate	5	68	75	5	0.156	NT
	Uranium	4	3	3.9	-6	0.0447	D

Key		
Increasing Trend		I
Decreasing Trend		D
No Trend		NT

Table 2: Summary table of Mann-Kendall trend analysis results from 2002 to 2016 for PW-4 and PW-5 wells.

PW-4 and PW-5 Wells (2002-2016)							
Wells Number	Parameter	General Statistics			Mann-Kendall Test		
		Number of Samples (n)	Min	Max	M-K (S)	Approximate p-value	M-K Trend
PW5	Arsenic	31	0.016	0.026	-191	4.81E-04	D
	Uranium	24	0.016	0.043	188	1.65E-06	I
	Sulfate	11	54	71	30	0.010	I
	Alkalinity, Total	11	120	140	22	0.0373	I
	pH	11	7.75	8.23	20	0.069	NT
PW4	Arsenic	28	8.20E-03	0.024	-56	0.137	NT
	Uranium	19	1.90E-02	0.047	31	0.146	NT
	Sulfate	7	4.10E+01	62	-8	0.144	NT
	Alkalinity, Total	7	130	210	3	0.375	NT
	pH	7	7.92	8.56	7	0.184	NT

Key		
Increasing Trend		I
Decreasing Trend		D
No Trend		NT

6 Appendices A

Summary table for both general statistics and M-K analysis for YPT wells and wells off reservation.

YPT Monitoring Wells (MW) (10 to 15)															
Well Number	Constituents	Number Values Reported (n)	Minimum	Maximum	Mean	Geometric Mean	Median	Standard Deviation	Coefficient of Variation	M-K Test Value (S)	Tabulated p-value	Standard Deviation of S	Standardized Value of S	Approximate p-value	M-K Trend
YPT MW-9I	Alkalinity, Bicarbonate	15	110	150	134.7	134.2	140	11.87	0.0882	63	0.001	19.45	3.188	7.17E-04	Yes (Increasing)
	Alkalinity, Total	15	110	150	134.7	134.2	140	11.87	0.0882	63	0.001	19.45	3.188	7.17E-04	Yes (Increasing)
	Arsenic	15	6.6	7.9	7.247	7.238	7.3	0.37	0.0511	-28	0.084	19.85	-1.36	0.0869	Insufficient Evidence
	pH	15	7.68	8.11	7.829	7.828	7.79	0.13	0.0166	1	0.5	20.16	0	0.5	Insufficient Evidence
	Sulfate	15	33	39	35.87	35.83	36	1.767	0.0493	-36	0.037	19.88	-1.76	0.0392	Yes (Decreasing)
	Uranium	15	8.7	11	9.807	9.788	10	0.63	0.0642	18	0.19	19.44	0.874	0.191	Insufficient Evidence
YPT MW-10B	Alkalinity, Bicarbonate	15	88	130	114.3	113.7	120	11.36	0.0994	35	0.046	19.04	1.786	0.037	Yes (Increasing)
	Alkalinity, Total	16	88	130	115.3	114.7	120	11.66	0.101	22	0.175	21.09	0.996	0.16	Insufficient Evidence
	Arsenic	16	19	21	19.81	19.8	20	0.655	0.0331	-7	0.412	19.59	-0.306	0.38	Insufficient Evidence
	pH	16	8	8.42	8.219	8.218	8.215	0.089	0.0108	20	0.199	22.17	0.857	0.196	Insufficient Evidence
	Sulfate	16	25	30	27.94	27.9	28	1.436	0.0514	-69	0.001	21.03	-3.233	6.12E-04	Yes (Decreasing)
	Uranium	16	8.3	11	9.231	9.212	9.15	0.635	0.0688	-10	0.345	22.11	-0.407	0.342	Insufficient Evidence
YPT MW-11S	Alkalinity, Bicarbonate	5	120	150	136	135.6	140	11.4	0.0838	-7	0.117	3.958	-1.516	0.0648	Insufficient Evidence
	Alkalinity, Total	5	120	150	136	135.6	140	11.4	0.0838	-7	0.117	3.958	-1.516	0.0648	Insufficient Evidence
	Arsenic	5	6.3	8.3	7.24	7.201	7.1	0.847	0.117	-6	0.117	4.082	-1.225	0.11	Insufficient Evidence
	pH	5	7.3	7.84	7.528	7.526	7.51	0.202	0.0268	-4	0.242	4.082	-0.735	0.231	Insufficient Evidence
	Sulfate	5	44	64	55.8	55.35	59	7.662	0.137	3	0.408	3.958	0.505	0.307	Insufficient Evidence
	Uranium	5	6.6	20	14.16	12.66	18	6.668	0.471	-8	0.042	4.082	-1.715	0.0432	Yes (Decreasing)
YPT MW-13I	Alkalinity, Bicarbonate	16	88	140	120.9	119.9	120	15.25	0.126	64	0.002	21.65	2.91	0.00181	Yes (Increasing)
	Alkalinity, Total	16	88	140	120.9	119.9	120	15.25	0.126	64	0.002	21.65	2.91	0.00181	Yes (Increasing)
	Arsenic	16	5.8	8.1	6.744	6.71	6.65	0.697	0.103	56	0.006	22.17	2.481	0.00655	Yes (Increasing)
	pH	16	7.49	7.93	7.765	7.764	7.815	0.132	0.0171	29	0.114	22.19	1.262	0.103	Insufficient Evidence
	Sulfate	16	33	42	37.56	37.49	37.5	2.449	0.0652	-36	0.058	21.94	-1.595	0.0553	Insufficient Evidence
	Uranium	16	4.6	9.1	6.969	6.784	6.9	1.642	0.236	95	0	22.14	4.245	1.09E-05	Yes (Increasing)
YPT MW-14D1	Alkalinity, Bicarbonate	16	92	130	105.9	105.3	100	12.01	0.113	38	0.048	21.71	1.704	0.0442	Yes (Increasing)
	Alkalinity, Total	16	92	130	105.9	105.3	100	12.01	0.113	38	0.048	21.71	1.704	0.0442	Yes (Increasing)
	Arsenic	16	15	19	17.19	17.13	17.5	1.424	0.0829	-40	0.039	21.56	-1.809	0.0352	Yes (Decreasing)
	pH	16	7.61	8.16	7.924	7.923	7.95	0.152	0.0192	-28	0.114	22.12	-1.221	0.111	Insufficient Evidence
	Sulfate	16	29	38	33.94	33.81	34.5	2.999	0.0884	-12	0.313	21.86	-0.503	0.307	Insufficient Evidence
	Uranium	16	10	18	13.44	13.25	13	2.337	0.174	47	0.021	21.7	2.12	0.017	Yes (Increasing)
YPT MW-15I	Alkalinity, Bicarbonate	12	230	340	282.5	280.3	290	36.96	0.131	19	0.125	14.39	1.251	0.105	Insufficient Evidence
	Alkalinity, Total	12	230	340	282.5	280.3	290	36.96	0.131	19	0.125	14.39	1.251	0.105	Insufficient Evidence
	Arsenic	12	5.7	6.5	6.092	6.088	6.05	0.207	0.0339	-39	0.004	14.15	-2.685	0.00363	Yes (Decreasing)
	pH	12	6.82	8.05	7.266	7.26	7.205	0.301	0.0414	-1	0.527	14.55	0	0.5	Insufficient Evidence
	Sulfate	12	42	56	47.75	47.54	46.5	4.789	0.1	-13	0.23	14.48	-0.829	0.204	Insufficient Evidence
	Uranium	12	15	34	24.33	23.74	24.5	5.466	0.225	10	0.273	14.58	0.617	0.269	Insufficient Evidence
YPT MW-12I	Alkalinity, Bicarbonate	16	160	260	192.5	190.2	180	32.15	0.167	38	0.048	21.73	1.703	0.0443	Yes (Increasing)
	Alkalinity, Total	16	160	260	192.5	190.2	180	32.15	0.167	38	0.048	21.73	1.703	0.0443	Yes (Increasing)
	Arsenic	16	3.6	5.6	4.738	4.706	4.9	0.554	0.117	-41	0.039	22.02	-1.816	0.0347	Yes (Increasing)
	pH	16	6.64	7.74	7.45	7.445	7.535	0.264	0.0354	11	0.345	22.14	0.452	0.326	Insufficient Evidence
	Sulfate	16	72	270	111.6	104	89.5	50.72	0.455	-34	0.07	22.17	-1.489	0.0683	Insufficient Evidence

Well Number	Constituents	Wells off Reservation (BW wells 10 to 81)													
		Number Values Reported (n)	Minimum	Maximum	Mean	Geometric Mean	Median	Standard Deviation	Coefficient of Variation	M-K Test Value (S)	Tabulated p-value	Standard Deviation of S	Standardized Value of S	Approximate p-value	M-K Trend
BW 10D1	Alkalinity, Bicarbonate	41	72	180	114.1	111	110	27.88	0.244	310	1.645	88.47	3.493	2.39E-04	Yes (Increasing)
	Alkalinity, Total	41	72	180	114.1	111	110	27.88	0.244	310	1.645	88.47	3.493	2.39E-04	Yes (Increasing)
	Arsenic	41	7.7	14	10.15	10.04	10	1.488	0.147	-306	-1.645	87.37	-3.491	2.41E-04	Yes (Decreasing)
	pH	41	7.25	8.33	8.009	8.006	8.04	0.182	0.0227	72	1.645	88.91	0.799	0.212	Insufficient Evidence
	Sulfate	41	33	56	44.1	43.71	44	5.826	0.132	414	1.645	88.84	4.649	1.67E-06	Yes (Increasing)
	Uranium	41	5.4	25	11.86	10.68	11	5.691	0.48	358	1.645	88.92	4.015	2.97E-05	Yes (Increasing)
BW 10S	Alkalinity, Bicarbonate	30	100	140	118	117.6	120	9.613	0.0815	47	1.645	53.13	0.866	0.193	Insufficient Evidence
	Alkalinity, Total	30	100	140	118	117.6	120	9.613	0.0815	47	1.645	53.13	0.866	0.193	Insufficient Evidence
	Arsenic	29	4.5	6.7	5.503	5.484	5.5	0.471	0.0856	-104	-1.645	52.98	-1.944	0.0259	Yes (Decreasing)
	pH	30	7.21	8.2	7.623	7.619	7.605	0.253	0.0332	59	1.645	55.99	1.036	0.15	Insufficient Evidence
	Sulfate	30	29	120	40.13	38.57	38	15.79	0.393	9	1.645	55.78	0.143	0.443	Insufficient Evidence
	Uranium	28	2.4	5.3	3.521	3.459	3.35	0.696	0.198	-93	-1.645	50.4	-1.825	0.034	Yes (Decreasing)
BW 53B	Alkalinity, Bicarbonate	20	110	160	134	133.5	130	12.31	0.0919	28	0.193	29.47	0.916	0.18	Insufficient Evidence
	Alkalinity, Total	20	110	160	134	133.5	130	12.31	0.0919	28	0.193	29.47	0.916	0.18	Insufficient Evidence
	Arsenic	20	6.3	16	13.58	13.31	14.5	2.37	0.175	45	0.082	29.13	1.511	0.0654	Insufficient Evidence
	pH	20	7.7	8.18	7.893	7.891	7.865	0.141	0.0179	-49	0.064	30.73	-1.562	0.0591	Insufficient Evidence
	Sulfate	20	140	170	158	157.9	160	6.959	0.044	-47	0.073	25.92	-1.775	0.038	Insufficient Evidence
	Uranium	20	8.8	11	10.07	10.04	9.95	0.781	0.0776	79	0.006	29.98	2.601	0.00464	Yes (Increasing)
BW 53S2	Alkalinity, Bicarbonate	17	120	140	128.2	128	130	7.276	0.0567	4	0.452	22.18	0.135	0.446	Insufficient Evidence
	Alkalinity, Total	17	120	140	128.2	128	130	7.276	0.0567	4	0.452	22.18	0.135	0.446	Insufficient Evidence
	Arsenic	17	11	15	12.76	12.74	13	0.831	0.0651	49	0.023	20.39	2.354	0.00928	Yes (Increasing)
	pH	17	7.7	8.19	7.939	7.938	7.88	0.155	0.0195	-45	0.038	24.26	-1.814	0.0348	Yes (Decreasing)
	Sulfate	17	140	170	153.5	153.3	150	8.618	0.0561	-30	0.118	22.06	-1.315	0.0943	Insufficient Evidence
	Uranium	17	8.4	12	10.06	10.02	9.8	1.028	0.102	31	0.118	23.98	1.251	0.105	Insufficient Evidence
BW 54B	Alkalinity, Bicarbonate	15	110	150	122.7	122.2	120	11	0.0897	3	0.461	19.14	0.104	0.458	Insufficient Evidence
	Alkalinity, Total	15	110	150	122.7	122.2	120	11	0.0897	3	0.461	19.14	0.104	0.458	Insufficient Evidence
	Arsenic	15	22	28	24.6	24.56	24	1.549	0.063	3	0.461	19.24	0.104	0.459	Insufficient Evidence
	pH	15	7.56	8.2	7.933	7.931	7.93	0.173	0.0218	-20	0.164	20.18	-0.941	0.173	Insufficient Evidence
	Sulfate	15	63	80	74.6	74.46	76	4.532	0.0608	-36	0.037	20.07	-1.744	0.0406	Yes (Decreasing)
	Uranium	15	15	20	17.8	17.73	18	1.612	0.0906	-11	0.313	19.76	-0.506	0.306	Insufficient Evidence
BW 54I	Alkalinity, Bicarbonate	15	140	180	160.7	160.4	160	9.612	0.0598	7	0.385	18.39	0.326	0.372	Insufficient Evidence
	Alkalinity, Total	15	140	180	160.7	160.4	160	9.612	0.0598	7	0.385	18.39	0.326	0.372	Insufficient Evidence
	Arsenic	15	21	26	22.87	22.84	23	1.246	0.0545	-17	0.218	18.93	-0.845	0.199	Insufficient Evidence
	pH	15	7.93	8.3	8.09	8.089	8.12	0.118	0.0146	-7	0.385	20.09	-0.299	0.383	Insufficient Evidence
	Sulfate	15	57	73	64.73	64.6	65	4.25	0.0657	-36	0.037	20.07	-1.744	0.0406	Yes (Decreasing)
	Uranium	15	30	38	33.73	33.68	34	2.017	0.0598	-54	0.003	19.85	-2.67	0.00379	Yes (Decreasing)
BW 54S	Alkalinity, Bicarbonate	15	140	180	158	157.7	160	9.411	0.0596	-11	0.313	18.28	-0.547	0.292	Insufficient Evidence
	Alkalinity, Total	15	140	180	158	157.7	160	9.411	0.0596	-11	0.313	18.28	-0.547	0.292	Insufficient Evidence
	Arsenic	15	18	21	19	18.98	19	0.926	0.0487	3	0.461	18.96	0.105	0.458	Insufficient Evidence
	pH	15	7.83	8.21	8.035	8.035	8.05	0.115	0.0143	-5	0.423	20.04	-0.2	0.421	Insufficient Evidence
	Sulfate	15	41	71	50.53	50.09	52	7.23	0.143	-64	0	20.07	-3.14	8.46E-04	Yes (Decreasing)
	Uranium	15	20	31	23.47	23.3	24	2.973	0.127	-54	0.003	19.65	-2.698	0.00349	Yes (Decreasing)

Well Number	Constituents	Number Values Reported (n)	Minimum	Maximum	Mean	Geometric Mean	Median	Standard Deviation	Coefficient of Variation	M-K Test Value (S)	Tabulated p-value	Standard Deviation of S	Standardized Value of S	Approximate p-value	M-K Trend	
BW 69D1	Alkalinity, Bicarbonate	6	230	250	241.7	241.5	245	9.832	0.0407	-9	0.068	4.865	-1.644	0.05	Insufficient Evidence	
	Alkalinity, Total	6	230	250	241.7	241.5	245	9.832	0.0407	-9	0.068	4.865	-1.644	0.05	Insufficient Evidence	
	Arsenic	6	3.7	4	3.817	3.814	3.75	0.147	0.0386	5	0.235	4.865	0.822	0.205	Insufficient Evidence	
	pH	6	7.5	8.08	7.757	7.753	7.68	0.266	0.0343	3	0.36	5.323	0.376	0.354	Insufficient Evidence	
	Sulfate	6	97	120	106.2	105.9	105	8.727	0.0822	-9	0.068	5.132	-1.559	0.0595	Insufficient Evidence	
	Uranium	6	50	59	53.83	53.73	52.5	3.764	0.0699	1	0.5	5.323	0	0.5	Insufficient Evidence	
BW 69D2	Alkalinity, Bicarbonate	6	110	130	121.7	121.5	120	7.528	0.0619	1	0.5	4.865	0	0.5	Insufficient Evidence	
	Alkalinity, Total	6	110	130	121.7	121.5	120	7.528	0.0619	1	0.5	4.865	0	0.5	Insufficient Evidence	
	Arsenic	6	5.4	5.8	5.6	5.598	5.6	0.179	0.0319	-2	0.36	5.033	-0.199	0.421	Insufficient Evidence	
	pH	6	7.91	8.21	8.03	8.029	8.01	0.104	0.013	9	0.068	5.323	1.503	0.0664	Insufficient Evidence	
	Sulfate	6	32	47	40.5	40.21	41	5.128	0.127	1	0.5	5.132	0	0.5	Insufficient Evidence	
	Uranium	6	5.9	11	8.617	8.477	8.75	1.636	0.19	5	0.235	5.323	0.751	0.226	Insufficient Evidence	
BW 69DS	Alkalinity, Bicarbonate	5	160	210	178	177.1	180	20.49	0.115	-6	0.117	3.83	-1.306	0.0958	Insufficient Evidence	
	Alkalinity, Total	5	160	220	182	180.9	180	22.8	0.125	-5	0.242	3.958	-1.011	0.156	Insufficient Evidence	
	Arsenic	5	6.4	13	10.32	10.02	11	2.602	0.252	8	0.042	4.082	1.715	0.0432	Yes (Increasing)	
	pH	5	8.1	8.61	8.306	8.304	8.26	0.191	0.023	-4	0.242	4.082	-0.735	0.231	Insufficient Evidence	
	Sulfate	5	34	41	38.2	38.12	38	2.683	0.0702	9	0.042	3.958	2.021	0.0216	Yes (Increasing)	
	Uranium	5	2.9	4.3	3.48	3.444	3.3	0.567	0.163	-2	0.408	4.082	-0.245	0.403	Insufficient Evidence	
BW 69S	Alkalinity, Bicarbonate	6	230	280	253.3	252.7	250	19.66	0.0776	-6	0.136	5.228	-0.956	0.169	Insufficient Evidence	
	Alkalinity, Total	6	230	280	253.3	252.7	250	19.66	0.0776	-6	0.136	5.228	-0.956	0.169	Insufficient Evidence	
	Arsenic	6	1.9	3.1	2.5	2.455	2.45	0.518	0.207	-8	0.068	5.228	-1.339	0.0903	Insufficient Evidence	
	pH	6	7.22	8.08	7.637	7.629	7.555	0.368	0.0482	7	0.136	5.323	1.127	0.13	Insufficient Evidence	
	Sulfate	6	120	130	125	124.9	125	5.477	0.0438	5	0.235	4.583	0.873	0.191	Insufficient Evidence	
	Uranium	6	7.8	30	18.37	16.05	18	9.739	0.53	-11	0.028	5.323	-1.879	0.0301	Yes (Decreasing)	
BW 81D1	Alkalinity, Bicarbonate	5	220	230	224	223.9	220	5.477	0.0245	-6	0.117	3.464	-1.443	0.0745	Insufficient Evidence	
	Alkalinity, Total	6	220	240	226.7	226.5	225	8.165	0.036	-11	0.028	4.865	-2.056	0.0199	Yes (Decreasing)	
	Arsenic	6	6.6	7.5	7.067	7.061	7.15	0.32	0.0453	4	0.235	5.228	0.574	0.283	Insufficient Evidence	
	pH	6	7.43	8.11	7.788	7.785	7.83	0.252	0.0324	7	0.136	5.323	1.127	0.13	Insufficient Evidence	
	Sulfate	6	68	83	75	74.73	74.5	7.014	0.0935	4	0.235	5.228	0.574	0.283	Insufficient Evidence	
	Uranium	6	36	47	39.5	39.33	38	4.087	0.103	4	0.235	5.228	0.574	0.283	Insufficient Evidence	
BW 81D2	Alkalinity, Bicarbonate	6	190	200	193.3	193.3	190	5.164	0.0267	4	0.235	4.32	0.694	0.244	Insufficient Evidence	
	Alkalinity, Total	6	190	200	193.3	193.3	190	5.164	0.0267	4	0.235	4.32	0.694	0.244	Insufficient Evidence	
	Arsenic	6	4.1	4.6	4.383	4.38	4.4	0.172	0.0393	0	0.5	5.228	N/A	N/A	Insufficient Evidence	
	pH	6	7.77	8.15	7.973	7.972	7.965	0.139	0.0175	7	0.136	5.323	1.127	0.13	Insufficient Evidence	
	Sulfate	6	46	57	50.83	50.66	50.5	4.622	0.0909	6	0.136	5.228	0.956	0.169	Insufficient Evidence	
	Uranium	6	34	43	37	36.84	35.5	3.795	0.103	12	0.008	4.967	2.215	0.0134	Yes (Increasing)	
BW 81S	Alkalinity, Bicarbonate	5	140	160	154	153.8	160	8.944	0.0581	-7	0.117	3.606	-1.664	0.048	Insufficient Evidence	
	Alkalinity, Total	5	140	160	154	153.8	160	8.944	0.0581	-7	0.117	3.606	-1.664	0.048	Insufficient Evidence	
	Arsenic	5	4.3	5.1	4.68	4.67	4.5	0.349	0.0746	-7	0.117	3.958	-1.516	0.0648	Insufficient Evidence	
	pH	5	7.11	7.8	7.398	7.394	7.38	0.264	0.0357	6	0.117	4.082	1.225	0.11	Insufficient Evidence	
	Sulfate	5	68	75	70.6	70.55	69	2.881	0.0408	5	0.242	3.958	1.011	0.156	Insufficient Evidence	
	Uranium	4	1	3	3.9	3.4	3.385	3.35	0.374	0.11	-6	0.042	2.944	-1.698	0.0447	Yes (Decreasing)

Summary table for both general statistics and M-K analysis for PW-4 and PW-5 Wells.

PW-4 and PW-5 Wells (2002-2016)															
Wells	Parameter	Number Values Reported (n)	General Statistics						Mann-Kendall Test						
			Minimum	Maximum	Mean	Geometric Mean	Median	Standard Deviation	Coefficient of Variation	M-K Test Value (S)	Tabulated p-value	Standard Deviation of S	Standardized Value of S	Approximate p-value	M-K Trend
PW5	Arsenic	31	0.016	0.026	0.022	0.022	0.021	0.002	0.107	-191	-1.645	57.55	-3.302	4.81E-04	D
	Uranium	24	0.016	0.043	0.029	0.028	0.032	0.008	0.263	188	1.645	40.21	4.651	1.65E-06	I
	Sulfate	11	54	71	64.64	64.35	66	6.265	0.097	30	0.008	12.46	2.327	0.010	I
	Alkalinity, Total	11	120	140	128.2	128	130	7.508	0.0586	22	0.043	11.78	1.783	0.0373	I
	pH	11	7.75	8.23	8.066	8.065	8.12	0.163	0.0202	20	0.06	12.81	1.484	0.069	NT
PW4	Arsenic	28	8.20E-03	0.024	0.015	0.015	0.017	0.004	0.267	-56	-1.645	50.27	-1.094	0.137	NT
	Uranium	19	1.90E-02	0.047	0.028	0.028	0.025	0.007	0.256	31	0.149	28.47	1.054	0.146	NT
	Sulfate	7	4.10E+01	62	50.71	50.28	52	7.111	0.14	-8	0.119	6.583	-1.063	0.144	NT
	Alkalinity, Total	7	130	210	158.6	157.1	150	24.78	0.156	3	0.386	6.298	0.318	0.375	NT
	pH	7	7.92	8.56	8.14	8.137	8.08	0.224	0.0276	7	0.191	6.658	0.901	0.184	NT